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Two taxa of the section *Contorta* of the genus *Batrachospermum* (Rhodophyta, Nemalionales*) from Iriomote Jima and Ishigaki Jima, subtropical Japan

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This paper deals with the taxomony of two taxa of the section *Contorta* of the genus *Batrachospermum*. One species and one variety are described here as new taxa: *Batrachospermum iriomotense* differs from *B. procarpum* in the size of the gonimoblast and from *B. intortum* in the absence of the monosporangia; *Batrachospermum tortuosum* var. *majus* differs from *B. tortuosum* in the size of the gonimoblast, carpospores and carpogonia. The biogeography of the genus *Batrachospermum* is also discussed here.

Key Index Words: Batrachospermum; Batrachospermum iriomotense; Batrachospermum tortuosum *var.* majus; *Nemalionales*; *Rhodophyta*; *section* Contorta; *taxonomy*.

The section *Contorta* was established by SKUJA (1931) as a tropical section for *Batrachospermum procarpum* SKUJA. The carpogonium bearing branch of this section is twisted spirally or bent like a hook. STARMACH (1977) included here *B. intortum* JAO 1941. The present author wishes to assign to this section *B. capensis* STARMACH 1975, *B. tortuosum* KUMANO 1978, *B. tiomanense* KUMANO et RATNASABAPATHY 1982 and *B. hirosei* RATNASABAPATHY et KUMANO 1982. In addition to the above mentioned species this paper deals with two taxa belonging to this section, viz., *B. iriomotense* KUMANO, sp. nov. and *B. tortuosum* KUMANO var. *majus* KUMANO, var. nov. from subtropical Japan. A key to the above mentioned taxa of the section *Contorta* is shown as follow:

KEY TO THE TAXA OF THE SECTION *Contorta*

1. Carpogonium bearing branch curved, consisting of 2-4 cells.
 2. Gonimoblast 220-300 μm in diameter. ..... *B. tortuosum* KUMANO var. *majus* KUMANO, var. nov.
 2. Gonimoblast 50-60 μm in diameter. ..... *B. tortuosum* KUMANO
1. Carpogonium bearing branch twisted, consisting of 3-8 cells. Gonimoblast 600-850 μm in diameter.. *B. capensis* STARMACH
1. Carpogonium bearing branch coiled, consisting of 6-13 cells.
 3. Gonimoblast up to 300 μm in width. ..... *B. procarpum* SKUJA
 3. Gonimoblast smaller than 220 μm in width.
  4. Monosporangia present. ..... *B. intortum* JAO
  5. Carposporangia 16-19 μm long. .. *B. iriomotense* KUMANO, sp. nov.
  5. Carpospornagia 8-15 μm long.
   6. Primary branchlet well-branched, its

* Many authors such as CHRISTENSEN (1962) and DIXON (1973) consider 'Nemaliales' to be the correct form. However, the author has followed FELDMANN (1976) in adopting this ordinal name, because J.G. AGARDH (1852) adopted Nemalionis in the genitive of Nemalion.

cells fusiform or ovoid.
.... *B. hirosei* RATNA. et KUMANO
6. Primary branchlet sparsely branched, its cells cylindrical.
..*B. tiomanense* KUMANO et RATNA.

Iriomote Jima and Ishigaki Jima

Iriomote Jima and Ishigaki Jima are islands situated at latitude 24°N and belong to the Yaeyama Shoto, a subtropical territory of Japan. Iriomote Jima is about 322 km² and has several rivers such as Urauchi-gawa and Hinai-gawa and small streams arising from peaks about 470 m above the sea level. Ishigaki Jima is about 258 km² and has several freshwater streams such as Miyara-gawa and Ara-kawa arising from Omoto Dake about 526 m above the sea level.

Descriptions and Observations

1. Batrachospermum iriomotense KUMANO, sp. nov. (Figs. 1, 3)

Frons monoica, 4-5 cm alta, 150-240 μm crassa, plus minusve abundanter irregulariterque ramosa, parum mucosa, badia. Cellulae axiales cylindricae, 20-90 μm crassae, 80-310 μm longae. Verticilli in parte mediana frondis rotundato-pyriformes, plerumque contigui. Ramuli primarii abundanter ramificantes, ex 8-10 cellulis constantes; cellulae fasciculorum lanceolato-ellipticae vel fusiformes; pili rari. Ramuli secundarii numersi, totum internodium obtegentes. Antheridia globosa, 3-7 μm diametro, in ramulis primariis et secundariis terminalia. Ramuli carpogoniferi e cellulis basi ramulorum primariorum orientes, longi, ex cellulis 8-12 disci- vel doliiformibus constantes, valde tortuosi;

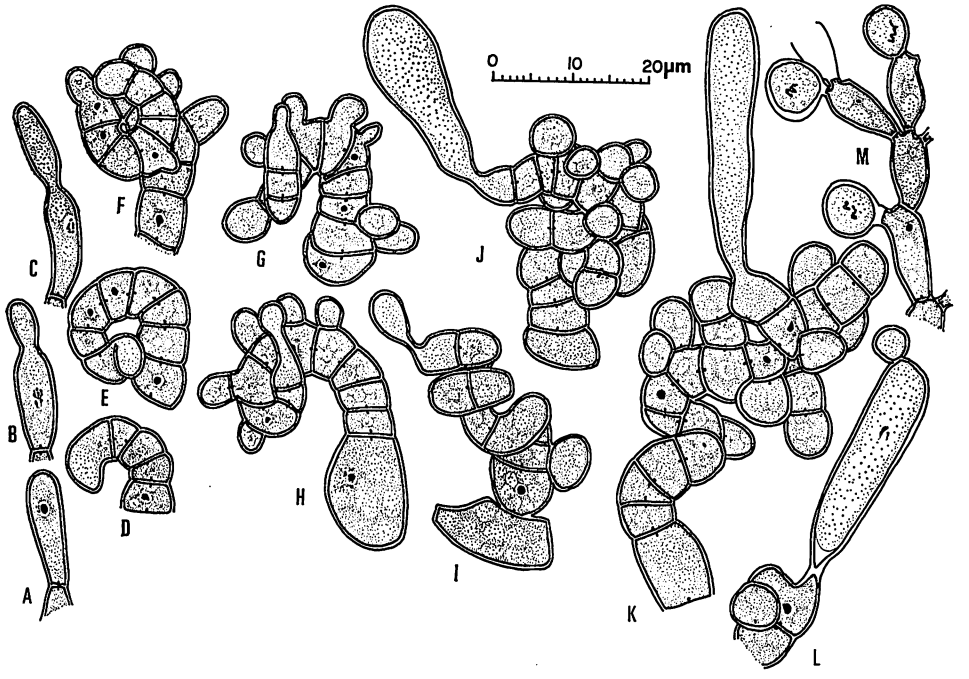

Fig. 1. *Batrachospermum iriomotense* KUMANO, sp. nov. A-C. The successive stages in nuclear divisions in a vegetative cells of a branchlet; D. A carpogonium initial at a very young stage and a carpogonium bearing branch; E-F. A carpogonium bearing branch coiled and twisted; G-H. The terminal portion of the carpogonium swelling out; I. The rounded initial of a trichogyne; J-K. A club-shaped trichogyne formed terminally on a carpogonium bearing branch, twisting twice or thrice; L. A fertilized carpogonium; M. The antheridia lateral or terminal on a primary branchlet.

carpogonium basi ca. 5 μm crassum, apice 6-8 μm crassum, 26-40 μm longum; trichogyne claviformis, indistincte pedicellata, ad basim saepe flexa. Bracteae numerosae, breves. Gonimoblasti singli, semiglobosi, magni, 100-220 μm crassi, 70-130 μm alti, in centro verticilli inserti. Carposporangia ellipsoidea vel ovoidea, 12-14 μm crassa, 16-19 μm longa.

Frond monoecious, 4-5 cm high, 150-240 μm wide, more or less abundantly and irregularly branched, not very mucilaginous, reddish brown. Axial cells cylindrical, 20-90 μm wide, 80-310 μm long. Whorls in middle portion of frond rounded pyriform, very frequently touching each other. Primary branchlet abundantly branched, consisting of 8-10 cell-stories; cells of fascicles lanceolate-ellipsoidal or fusiform; hairs rare. Secondary branchlets numerous, covering all internode. Antheridia globose, 3-7 μm in diameter, terminal on primary and secondary branchlets. Carpogonium bearing branch arising from the basal cell of primary branchlet, long, consisting of 8-12 disc- or barrel-shaped cells, very twisted; carpogonium about 5 μm wide at the base, 6-8 μm wide at the apex, 26-40 μm long; trichogyne club-shaped, indistinctly stalked, often bent at the base. Bracts numerous, short. Gonimoblast single, semiglobular, big, 100-220 μm wide, 70-130 μm high, inserted centrally. Carposporangia ellipsoidal or ovoid, 12-14 μm wide, 16-19 μm long.

Holotypus: Sira-gawa, Iriomote Jima, Okinawa, Japan (MATSUMOTO, 23/III 1974, Herbarium of Faculty of Science, Kobe University). Isotypus: Herbarium of Faculty of Science, Hokkaido University, SAP.

Habitat: This species grows on rock and stones in small mountain streams.

Distribution: Known from the type locality and Kedah Peak, Kedah, Malaysia (RATNASABAPATHY No. 108, 15/V 1979).

This species resembles *B. capensis* STAR-

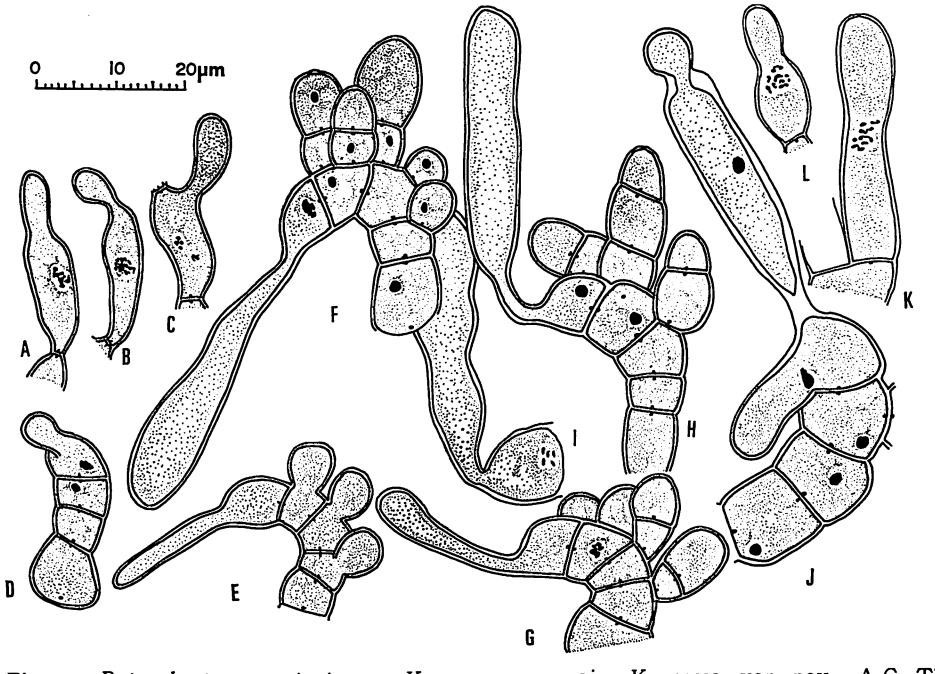

Fig. 2. *Batrachospermum tortuosum* KUMANO var. *majus* KUMANO, var. nov. A-C. The successive stages of nuclear divisions in a vegetative cell of a branchlet; D. A very young carpogonium bearing branch with a carpogonium initial; E-G. The curvature of a carpogonium bearing branch and the formation of a slightly asymmetrical trichogyne initial; H. A well-developed trichogyne bending at the base; I. A fertilized carpogonium; J. An initial of a gonimoblast filament; K-L. Terminal cells of the gonimoblast filaments.

MACH 1975 in general appearance, but differs in the size. In *B. capensis*, whorls are 400-580 μm wide, carpogonia 40-63 μm long, gonimoblasts 600-850 μm in diameter and carpospores 12-15 μm long, while in *B. iriomotense*, whorls are 150-240 μm wide, carpogonia 26-40 μm long, gonimoblast 100-220 μm wide and carposporangia 16-19 μm long. This species resembles more closely *B. intortum* JAO 1941 in the shape of the trichogyne, but differs in the absence of monosporangia.

Observations: Nuclear divisions of the vegetative branchlets occur after cell elongation as shown in Fig. 1 A-C. With the respect to the carpogonium the terminal cell of the carpogonium bearing branch swells out (Fig. 1 D-G), becomes the rounded initial of a trichogyne (Fig. 1 H-I) and turns into a club-shaped trichogyne with an indistinct stalk (Fig. 1 J-L). The trichogyne is somewhat asymmetrical and sometimes bends at the basal portion consequently facing the outside of the whorl (Fig. 1 I-K). During the development, as the number of cells composed of a carpogonium bearing branch increases, it gradually grows to become coiled and twisted (Fig. 1 D-K). The number of twists may be two or three. After fertilization, the gonimoblast grows out into radially branched and somewhat loosely aggregated filaments, which form a hemispherical structure inserted centrally. The gonimoblast is very conspicuous although smaller than the whorl.

2. Batrachospermum tortuosum KUMANO var. **majus** KUMANO, var. nov.

(Figs. 2, 4)

Frons monoica, 4-7 cm alta, 330-600 μm

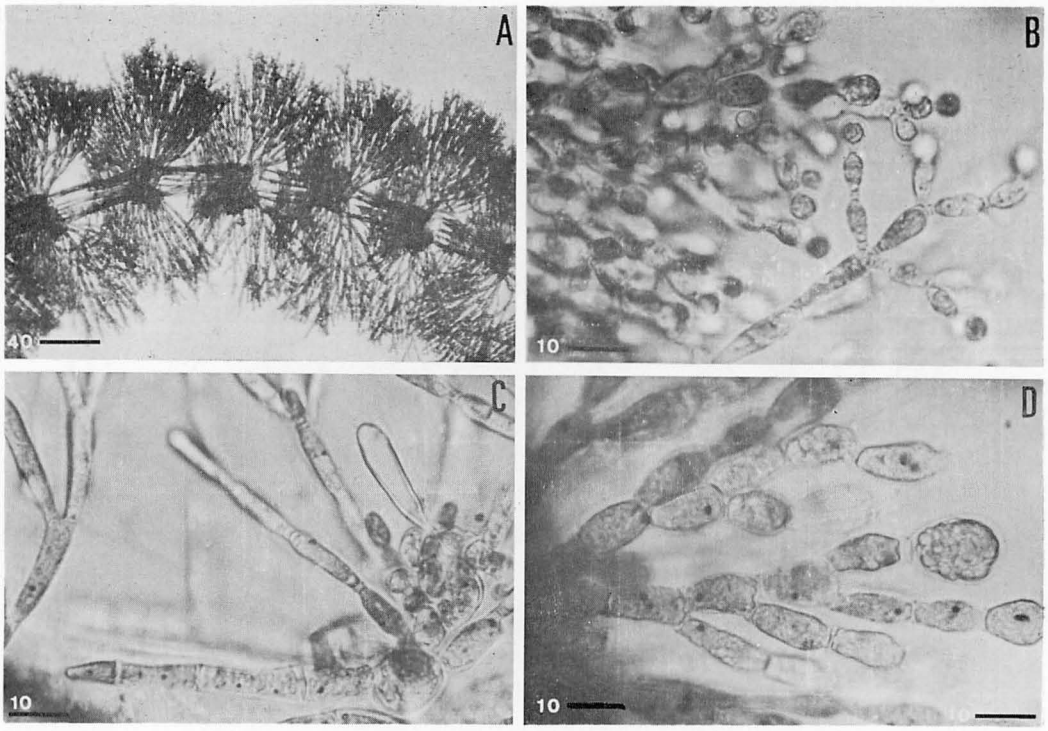

Fig. 3. *Batrachospermum iriomotense* KUMANO, sp. nov. A. A part of young thallus showing axial cells, primary branchlets, cortical filaments, secondary branchlets and young gonimoblasts inserted centrally; B. The antheridia lateral or terminal on primary branchlets; C. A club-shaped trichogyne formed on a twisted carpogonium bearing branch; D. The radially branched gonimoblast filaments, rather loosely aggregated and bearing carposporangia terminally. (Scale: 40 μm for A, 10 μm for B, C and D).

crassa, abundanter irregulariterque ramosa, parum mucosa, olivaceo-viridis. Cellulae axiales cylindricae, 30-60 μm crassae, 200-480 μm longae. Verticilli aut distantes et ellipsoidei aut contigui et plus minusve compressi. Ramuli primarii abundanter ramificantes, ex 10-12 cellulis constantes; cellulae fasciculorum pyriformes vel obovoideae; pili nuli. Ramuli secundarii longi, numerosi, mox totum internodium obtegentes. Antheridia globosa, 5-7 μm diametro, in ramulis primariis terminalia. Ramuli carpogoniferi e cellulis basi ramulorum primariorum orientes, 10-40 μm longi, ex cellulis 2-4 disci- vel doliiformibus constantes, plus minusve curvi; carpogonium basi 8-9 μm crassum, apice 6-9 μm crassum, 33-60 μm longum; trichogyne claviformis, indistincte pedicellata, ad basim saepe flexa. Bracteae numerosi, breves. Gonimoblasti singli, semiglobosi, magni, 220-300 μm crassi, 170-280 μm alti, in centro verticilli inserti. Carposporangia globosa vel ovoidea, 10-16 μm crassa, 14-19 μm longa.

Frond monoecious, 4-7 cm high, 330-600 μm wide, abundantly and irregularly branched, not very mucilaginous, olive-green. Axial cells cylindrical, 30-60 μm wide, 200-480 μm long. Whorls ellipsoidal and distant or touching each other and more or less compressed. Primary branchlet abundantly branched, consisting of 10-12 cell-stories; cells of fascicles pyriform or obovoid; hairs none. Secondary branchlets long, numerous, soon covering all internodes. Antheridia globose, 5-7 μm in diameter, terminal on primary branchlets. Carpogonium bearing branch arising from the basal cell of primary branchlet, long, consisting of 2-4 disc- or barrel-shaped cells, more or less curved; carpogonium 8-9 μm wide at the base, 6-9 μm wide at the apex,

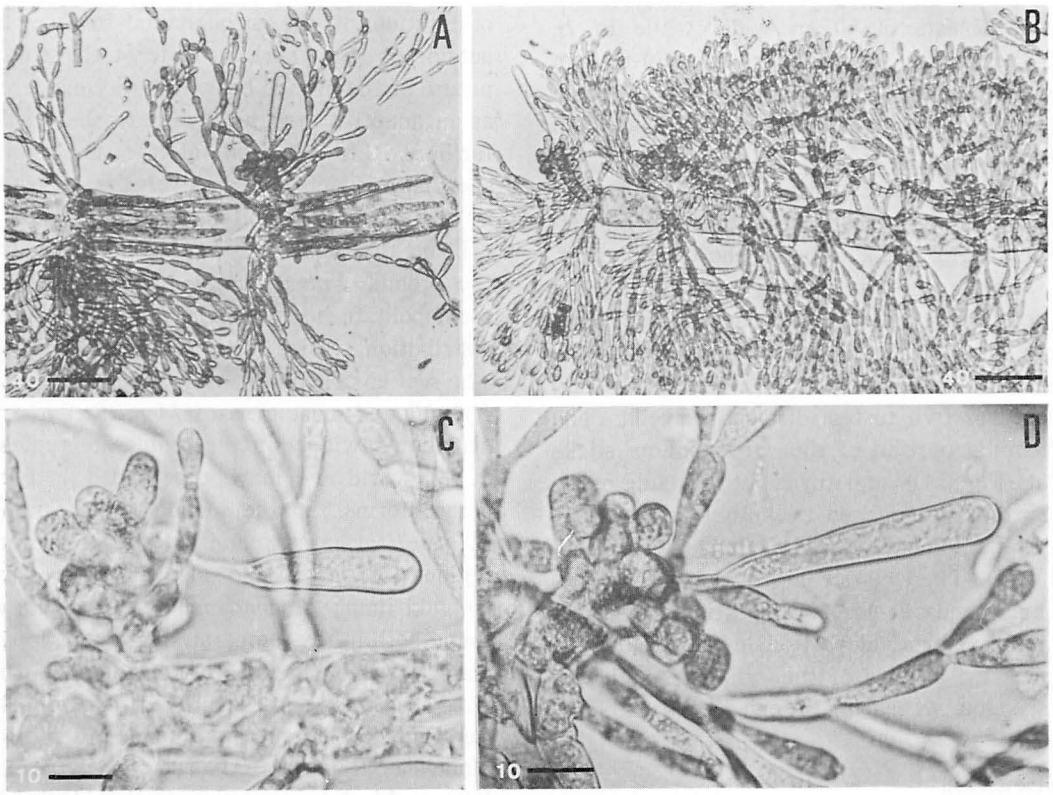

Fig. 4. *Batrachospermum tortuosum* KUMANO var. *majus* KUMANO, var. nov. A-B. A part of thallus showing axial cells, primary branchlets, cortical filaments and carpogonia with well-developed trichogynes; C-D. The curved carpogonium bearing branch with the long club-shaped trichogyne indistinctly stalked. (Scale: 40 μm for A and B, 10 μm for C and D).

33-60 μm long; trichogyne club-shaped indistinctly stalked, often bent at the base. Bracts numerous, short. Gonimoblast single, semiglobular, big, 220-300 μm wide, 170-280 μm high, inserted centrally. Carposoporangia globose or ovoid, 10-16 μm wide, 14-19 μm long.

Holotypus: Miyara-gawa, Ishigaki Jima, Okinawa, Japan (KUMANO, 5/IV 1977, Herbarium of Faculty of Science, Kobe University). Isotypus: Herbarium of Faculty of Science, Hokkaido University, SAP.

Habitat: This variety grows on gravel in mountain streams.

Distribution: Known from the type locality and Urauchi-gawa, Iriomote Jima, Okinawa, Japan (MATSUMOTO, 23/III 1974).

This variety differs from *B. tortuosum* KUMANO 1978 in the size; in *B. tortuosum*, whorls are 200-300 μm wide, axial cells 40-170 μm long, carpogonia 30-35 μm long and gonimoblasts 50-60 μm wide, while in *B. tortuosum* var. *majus*, whorls are 330-600 μm wide, axial cells 200-600 μm long, carpogonia 33-60 μm long and gonimoblasts 220-300 μm wide.

Observations: The nuclear division of vegetative branchlets occurs after cell elongation (Fig. 2 A-C). During the development, the carpogonium bearing branch becomes curved (Fig. 2 E-H). The carpogonium bearing branch of this variety arises from the basal cell of primary branchlets and is composed of two to five disc-shaped cells. The terminal portion of the carpogonium sticks out (Fig. 2 D), and turns into a young cylindrical or club-shaped trichogyne initial (Fig. 3 E) built more or less asymmetrically (Fig. 2 E-H). The well-developed trichogyne sometimes bends at the basal portion (Fig. 2 H), thus the terminal portion of the trichogyne faces the outside of the whorl though the carpogonium bearing branch curves adaxially.

Discussion

The section *Contorta* had a characteristic in having a twisted or curved carpogonium bearing branch, but its length varies from species to species. The cell number of the carpogonium bearing branch is reduced, being five to three in *B. tortuosum*, and four to two in *B. tortuosum* var. *majus*, In the latter the carpogonium bearing branch becomes curved and a big gonimoblast is inserted centrally within a whorl. The carpogonium bearing branch of *B. capensis* is composed of three to eight cells, and that of *B. iriomotense* is eight to twelve disc-shaped cells. However, in both these taxa the much coiled and twisted carpogonium bearing branch with the resultant central insertion of the large gonimoblast obscures the true length of the branch. The coiled carpogonium bearing branch is also found in the genus *Tuomeya*. Hence, it can be considered that there is a close phylogenetic relationship between the section *Contorta* of the genus *Batrachospermum* and the genus *Tuomeya*.

In both the new taxa described here, the orientation of the carpogonium to face the outside of the whorl, in spite of the coiled nature of the branch bearing it, is considered as an adaptive structural feature that could faciliate the adhesion of the non-motile spermatia which are passively transported by water to its vicinity.

From the biogeographical point of view, the genus *Batrachospermum* is generally cosmopolitan, however, the pattern of the distribution varies from species to species. The sections *Helminthoidea*, *Setacea*, *Viridia*, *Hybrida* and most taxa of *Moniliformia* are distributed widely in the temperate regions of the world and may be regarded as temperate forms. In the section *Moniliformia*, *B. moniliforme* is found in the temperate regions of Japan and also in subtropical Ishigaki Jima; *B. monilforme* var. *scopula* is found both in the temperate regions of Japan and in Yaku Shima of subtropical Japan. *B. godronianum* is distributed more widely ranging from temperate Japan to tropical Malaysia (RATNASABAPATHY and KUMANO 1982a). Most taxa of the section *Contorta* have been reported from tropical regions; *Batrachospermum procarpum* reported from Brazil by SKUJA (1931), *B. capensis* from the

Seychelles by STARMACH (1975), *B. tortuosum* by KUMANO (1978), *B. tiomanense* and *B. hirosei* by RATNASABAPATHY and KUMANO (1982a, b) from tropical Malaysia. While *B. intorum* was reported from temperate China by JAO (1941), *B. iriomotense* and *B. tortuosum* var. *majus* are reported here from Iriomote Jima and Ishigaki Jima of subtropical Japan. On the other hand, *B. cylindrocellulare* (KUMANO 1978) and *B. lochmodes* (SKUJA 1938) of *Moniliformia* are limited to the tropical regions of Malaysia and Indonesia respectively. The section *Aristatae* has been regarded as a tropical one (SKUJA 1933), and in this connection the recent report by KUMANO (1978) on *B. beraense* of this section from Malaysia is of interest.

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熊野　茂：亜熱帯日本の西表島と石垣島産カワモヅク属コントルタ節（紅藻ウミゾウメン目）の新種および新変種

西表島と石垣島からカワモヅク属コントルタ節の新種と新変種とが記載された。*Batrachospermum iriomotense* KUMANO は *B. procarpum* SKUJA とは嚢果の大きさで異り，*B. intortum* JAO とは単胞子を持たない点で区別できる。*B. tortuosum* KUMANO var. *majus* KUMANO は *B. tortuosum* KUMANO とは嚢果，果胞子および造果器の何れもが大型である点が異る。カワモヅク属とツオメア属との類似点，カワモヅク属の分布なども考察された。（657 神戸市灘区六甲台町　神戸大学理学部生物学教室）